Building the business case for Tobacco Control

A toolkit to estimate the economic impact of tobacco

TECHNICAL REPORT

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London Health Observatory

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Tobacco Free Futures
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This report describes the work carried out by the consortium involving Health Economics Research Group at Brunel University, Queen's Medical Centre at University of Nottingham and London Health Observatory. Tobacco Free Futures, Smokefree South West and Fresh- Smoke Free North East commissioned this work. The consortium was led by Health Economics Research Group at Brunel University.

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Supplements:

1. MS Excel/Web-based toolkit: Economic model of tobacco control
2. User Guide: Economic model of tobacco control
3. Tobacco Control Economic Toolkit Background and Rational Report
4. Tobacco Control Economic Toolkit Technical Report (this document)

Disclaimer:

This toolkit when available on the web can be freely accessed and used for building business cases for tobacco control. This is primarily intended for commissioners, public health professionals, regional managers and policy-makers. The toolkit has been developed using the current best practice and available data, and while doing so, a number of assumptions have been made. It is the responsibility of the users to understand the workings of the model and accept the assumptions underlying it. The Project team and the sponsors, therefore, accept no liability for any adverse consequence arising from the use of this toolkit. The users are expected to acknowledge the source in any form of verbal and written communications.

Request to the users:

This toolkit may be subject to continuous improvement. If any problem is encountered or inconsistency is found, please report it by email (Subhash.Pokhrel@brunel.ac.uk). The following citation is recommended:
Trapero-Bertran M, Pokhrel S, Trueman P. An economic model of tobacco control version 1. Tobacco Free Futures, Fresh Smoke Free North East & Smokefree South West. December 2011.

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Executive summary

This report - to be read alongside the 'Building the Case for Tobacco Control: Tobacco Control Report' - provides detailed information relating to the technical aspects of the economic model developed a summary of the evidence used to develop the tobacco control toolkit which aims to support local commissioners to make evidence based decisions around tobacco control commissioning. This report also provides the summary evidence around tobacco health and economic costs and explains how these have been used to develop a practical financial tool to model these at the locality level- based upon local authority boundaries. An explanation of the purpose of the toolkit including the limitations of previous models is provided. The assumptions made in this model particularly around the use of a Markov model and the calculation of the background quit rates is explained.

Detail is provided on how this model then generates estimates of the impact of investment in different 'packages' of measures to combat smoking and allows commissioners to consider the impact of supplementing local stop smoking services and local tobacco control activity with a sub-national co-ordinated tobacco control programme. Using the most recent data from the Integrated Household Survey, the model predicts the number of smokers and former smokers in the short-, medium- and long-terms in the chosen area and translates this to a number of health and economic consequences, including:

- Primary care consultations and their associated costs;
- Secondary care admissions and their associated costs;
- Productivity losses resulting from smoking related illnesses;
- The number of smoking related illnesses;
- The number of new smokers;
- Exposure to passive smoking.

The key advantages of the current model, compared to similar analyses conducted previously are detailed including: the ability to examine the smoking population at a national, sub-national and local level; the ability to quantify the short-term impacts of smoking on the health service and society more generally; and the ability to explore the impact of a comprehensive tobacco control strategies in combination with local provision of stop smoking services.

An illustrative example from the North West of England is provided to show the model calculations in more detail and the level of savings made through the investment in a sub-national programme complimented by local stop smoking services. Finally, this report provided technical annexes to substantiate the detailed calculations undertaken within the economic modelling excel toolkit.

1. Background

As discussed in the accompanying report, 'Tobacco Control background' the adverse health effects of tobacco are well recognised (1-7). It is the cause of many preventable diseases, leads to premature death and is a significant contributor to health inequalities. Whilst significant progress has been made in reducing the prevalence of tobacco use in England with approximately 2 million fewer smokers today than there were a decade ago, smoking has not diminished as a public health priority. More than 1 in 5 adults – over 8 million people in the United Kingdom – continue to smoke according to the latest available figures (2) creating a significant burden for the health service and society as a whole. Furthermore, whilst there has been a downward trend in smoking prevalence over several decades, this appears to have stagnated since 2007.

England has made substantial progress in reducing smoking prevalence and tobacco-related harm but the scale of the problem is such that faster progress is a priority. Less affluent smokers continue to have a higher smoking prevalence than more affluent smokers and more needs to be done to narrow the gap.

Estimates of the health and broader economic effects of tobacco use are manifold. The latest estimates of smoking attributable mortality suggest that over 80,000 people die as a result of smoking related illnesses each year. Around a half of long-term smokers will die as a result of their addiction. A further 10,000 deaths per year are caused by second-hand smoke. Deaths from smoking are more numerous than the next six most common causes of preventable death combined (i.e. drug use, road accidents, other accidents and falls, preventable diabetes, suicide and alcohol abuse). On this basis, there remains a strong public health case for further investment in tobacco control.

The economic case for tobacco control is also robust. Tobacco related illnesses are estimated to cost the NHS almost £3bn per year (1). The broader societal impacts include lost productivity as a result of ill-health and premature death amongst smokers, environmental impacts and domestic fires.

Investing in improved tobacco control and services to help smokers quit can result in savings to the health service and society more generally. There is a significant body of evidence to support the cost effectiveness of interventions designed to help smokers quit. A report by Action on Smoking and Health (ASH) has estimated the reduction in smoking prevalence since 1996 to be associated with a £400 million (13%) reduction in NHS costs (6). A review of the evidence on the impact of smoking regulation suggests that reducing smoking in public places has had a rapid effect on health outcomes, including the number of admissions for cardiovascular disease and respiratory illness.

As policy shifts responsibility for public health from the health sector to local authorities, these bodies also need good quality evidence and estimates of the broader, societal impacts of tobacco control. In light of the economic challenges facing the public sector, funding for all public services, healthcare and public health is coming under increased scrutiny. The Department of Health White Paper on public health 'Healthy Lives, Healthy People', issued in November 2010 (8) makes it clear that tobacco use remains a public health priority:

Following on from the Public Health white paper, a tobacco plan for England was published by the Government in March 2011 (9) and it signals a continued focus on tobacco issues. The plan sets out an aim to reduce smoking rates faster in the next five years than has been achieved in the past five years. It has set out three new national ambitions to get prevalence back on the downward curve:

1. To reduce adult (aged 18 or over) smoking prevalence in England to 18.5 per cent or less by the end of 2015 (from 21.2 per cent), meaning around 210,000 fewer smokers a year.
2. To reduce rates of regular smoking among 15 year olds in England to 12 per cent or less (from 15 per cent) by the end of 2015.
3. To reduce rates of smoking throughout pregnancy to 11 per cent or less (from 14 per cent) by the end of 2015 (measured at time of giving birth).

It is imperative that a strong economic case is made to support continued investment in tobacco control across the country and in services to support smokers to stop at a time when public sector finances are under significant pressure. In light of this, a toolkit has been developed to help illustrate the financial impacts of tobacco and how these might be moderated through the use of comprehensive, sub-national tobacco control programmes. In this report, we describe the work that was carried out to explore the economic impacts of tobacco and communicate these in a way that resonates with commissioners in health and local authorities.

2. The rationale for developing the toolkit- the economics of tobacco

The cost of managing the adverse health impacts of tobacco use

The negative health impacts of tobacco are clear. The use of tobacco results in significant mortality each year. In England, over 80,000 people die every year due to tobacco-related disease (1). In addition to this, tobacco related illnesses are responsible for excess primary care consultations, hospitalisations and prescriptions. The consequences of smoking, the largest form of tobacco use, are not limited to smokers only - smoking also affects those who are not smokers themselves but are exposed to second-hand smoke. The scale of the impact this form of smoking - commonly known as 'passive' or 'environmental' or 'second-hand' smoking'- has on society is significant and is particularly harmful to children. The Royal College of Physicians estimates that passive smoking causes 40 sudden infant deaths, over 300,000 GP consultations and about 9,500 hospital admissions in the UK each year (10).

A number of previous studies have sought to estimate the cost to the NHS of managing smoking related illnesses with the most recent study estimating that tobacco related illness accounts for around 5% of total NHS expenditures. A summary of the findings of pivotal studies is included in the table below.

Table 1: Estimated cost to the NHS of smoking attributable illness

Source	Estimated cost to NHS	Adjusted to 2009 prices
Allender et al 2009 (1)	£5.2bn	£5.2bn
Callum et al 2006 (11)	£2.7bn	£3.0bn
Parrott et al 1998 (12)	£1.4-1.7bn	£1.8-2.2bn

The disparities in the estimated economic impact of tobacco arise from differences in the methodologies employed. In all cases, the studies estimate the cost of tobacco related illness by first identifying conditions that are associated with tobacco, then estimating the proportion of cases that are likely to be attributable to tobacco. Differences might arise due to different conditions being included, different proportions being attributed to tobacco and different costs of managing each condition being adopted (see Technical Annex).

However, regardless of the methodology one thing is clear – tobacco use and its effects create a significant burden for local economies, the NHS and society more generally. The most recent estimates suggest that

tobacco related illness accounts for over 5% of healthcare expenditure. The fact that the health and economic impacts stem from a highly addictive but legal product which has been cleverly marketed by a global industry creates a sense of frustration in some quarters. As the Royal College of Physician's Report on passive smoking and children puts it, *"the entire excess disease burden is avoidable" and "the significant costs [due to this excess burden] are all avoidable"* (10).

The societal impact of tobacco

The economic consequences of tobacco are not confined to our health economy and impact more broadly on society. Every year, tobacco costs businesses about £2 billion in the form of absenteeism and smoking breaks (known as 'productivity losses') (13). Tobacco related products are a major cause of fires and in England the cost of smoking related house fires is estimated at £507 million each year (14). As smokers die prematurely often at working age, £4 billion is lost each year, a phenomenon known as 'employment losses' to the businesses (15). In addition, many smokers need payments, in the form of sickness and incapacity benefits, because they suffer from diseases caused by smoking. There may also be pension and other benefit payments to families of those who die as a result of their smoking. The environmental costs of costs associated with cleaning used tobacco products, such as cigarette butts, are non-negligible and estimated to be £342 million per year (15).

It is often argued that tobacco is a net contributor to the economy through taxation revenues. However, the recent study from the Policy Exchange (15) dispels this myth, suggesting that taxation generates around £10bn per year whilst the adverse effects of tobacco cost society somewhere in the region of £13bn per year. In short, tobacco use represents a sizeable net economic cost to society

3. Explanation of the toolkit

There is a vast body of literature on the economics of tobacco use, much of which makes a case for the cost effectiveness of individual interventions (see Technical Annex). Whilst much of the evidence is robust and well defined, there are a number of shortcomings associated with many of these studies:

1. Firstly, in practice tobacco control interventions are rarely commissioned in isolation and there is a need to consider how a portfolio of interventions, comprising tobacco control and smoking cessation might work collectively.
2. Secondly, there is a need to consider how such interventions might impact at the level of the local health economy. Many of the analyses produced to date generate high-level estimates of the cost of smoking to the nation which do not resonate with those who are responsible for the commissioning, planning and delivery of local services who want to see estimates of the costs and benefits in their locality.
3. Thirdly, many of the analyses consider the lifetime costs of smoking to an individual smoker or a cohort of smokers. Whilst this is a useful approach to capture the effects on long-term endpoints, such as mortality, most commissioners to much shorter time-horizons and want to know how their investment in tobacco control might impact on outcomes and costs in the near term.

The toolkit is intended to support commissioners, in health and local authorities, to consider the impacts of tobacco on a range of health and non-health outcomes measured in financial and non-financial terms. The toolkit comprises:

- An economic model that allows the user to undertake bespoke analyses of strategies and programmes to tackle tobacco at a national, sub-national and local level, using pre-populated data;
- A user guide to support local use of the toolkit;
- A technical report (this one), supplemented with technical annexes detailing the methods employed in the development of the model.
- A background and rationale report providing the justification for tobacco control

The model generates estimates of the impact of investment in different ‘packages’ of measures to combat smoking and allows commissioners to consider the impact of supplementing local stop smoking services services with a sub-national co-ordinated tobacco control programme.

Using the most recent data from the Integrated Household Survey, the model predicts the number of smokers and former smokers in the short-, medium- and long-terms in the chosen area and translate this to a number of health and economic consequences, including:

- Primary care consultations and their associated costs;
- Secondary care admissions and their associated costs;
- Productivity losses resulting from smoking related illnesses;
- The number of smoking related illnesses;
- The number of new smokers;
- Exposure to passive smoking.

The key advantages of the current model, compared to similar analyses conducted previously include:

- The ability to examine the smoking population at a national, sub-national and local level;
- The ability to quantify the short-term impacts of smoking on the health service and society more generally;
- The ability to explore the impact of a comprehensive tobacco control strategies in combination with local provision of stop smoking services.

4. Assumptions underlying the model and the background quit rate

The model builds on previous analyses of tobacco control and provision of support to stop smoking. However, given that it is intended for sub-national and local decision makers there are a number of deviations from previous analyses. Crucially, the model attempts to generate outcomes in the short, medium and long-term, allowing commissioners to estimate the short-term return on investment in regional and locally co-ordinated tobacco control initiatives. Whilst longer term outcomes are included and remain important, it is acknowledged that the current funding environment means that commissioners are inevitably focussed on returns over a shorter period of time.

Secondly, the model attempts to capture the impacts of tobacco beyond healthcare by capturing evidence on productivity losses. This is an attempt to make the findings relevant to commissioners and stakeholders outside of healthcare, including local authorities and private sector employers.

Finally, the model also attempts to capture the impact of passive smoking on adults and children. This has not been attempted in previous analyses and adds an extra dimension to the current model.

The model is built in Microsoft Excel in order to ensure that it is readily available to commissioners. The model is pre-populated with data on smoking prevalence at a local authority level, using data from the Integrated Household Survey, co-ordinated by the Office of National Statistics. The model is intended to be an interactive tool, for use by commissioners and planners. As such, many of the parameters in the model can be amended to reflect local circumstances. These include local prevalence estimates, wage rates and absenteeism associated with smoking and the underlying quit rate.

4.1 Markov model

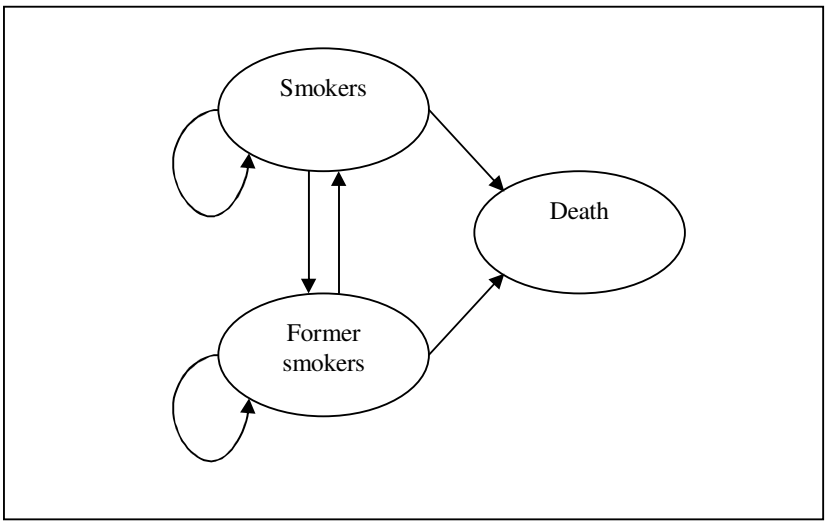
The model is a simple 'Markov' model which includes three states, smokers, former smokers and death. The model considers the population of a specific region/area. The population is divided into current smokers, former smokers and non-smokers, who may enter the model if they take up smoking ('new smokers').

Individuals in each of the health states have a risk of developing a number of smoking related conditions – i.e. a current smoker will have the highest risk of developing an adverse outcome, followed by a former smoker, followed by a non-smoker. Smoking related conditions considered in the model include lung cancer, coronary heart disease, chronic obstructive pulmonary disease, myocardial infarction and stroke.

A cohort of individuals is followed in the model. Individuals can move between each of the smoking states each year. That is, in any given year an individual might continue to smoke, stop smoking and become a former smoker or die.

The current model is an adapted version of the model developed by Flack et al. 2007 (16). A cohort of smokers in the chosen area/region is followed up over two years (for short-term outcomes), over 10 years (for medium-term outcomes) and over their lifetime (for long-term outcomes) in a yearly cycle.

Figure 1: The schematic representation of the model is given below [adapted from Flack et al. 2007 (16)]



4.2 Estimating the counter-factual: the background quit rate

Our analysis assumes that there exists an underlying 'background' quit rate amongst smokers. This represents those successful quit attempts that occur through self-motivation and might be considered to represent the impact of underlying changes in attitudes in relation to tobacco use. This can be derived from analysis of long-term data on the prevalence of smoking in the general population. The underlying challenge is identifying a longitudinal data set that allows for factors that might influence the background quit rate to be controlled (such as changes in regulation).

The model assumes that there is an underlying 'background' quit rate occurring due to social norm changes. This reflects the reduction in smoking prevalence that occurs due to successful quitting as a result of self-motivation, education and national and local tobacco control initiatives and interventions. The background quit rates provides an important parameter for the model – the success of any tobacco control interventions, including provision of support to stop smoking is considered in reference to this estimate.

The derivation of the 'background quit rate' is complex. Ideally, this would be based on a longitudinal analysis of a cohort of smokers, controlling for any potentially confounding factors, such as changes in regulation. In reality, such datasets are hard to find and there is a tendency to rely on repeated panel surveys to estimate changes in prevalence over time. (See technical annex)

A number of previous analyses have sought to establish this 'background quit rate' amongst smokers (16-19). Table A9 in the Technical Annex provides a summary of the rates adopted in recent analyses. Many of these analyses, particularly more recent studies, point to the work being carried out under Smoking Toolkit Study (20) that has analysed national prevalence data and quit rates over time. The findings suggest that quit rates over the last 40 years have typically been between 1-2% per annum.

For the purposes of our analysis, we have adopted a national background quit rate of 2% per annum – that is 2% of smokers are assumed to quit each year through self-motivation, assisted or unassisted.

The background quit rate provides a basis against which we can compare the effects of strategies designed to reduce tobacco consumption.

4.3 Using the model to make a business case for tobacco control

The model allows the user to explore the impact of the provision of local stop smoking service interventions with or without the presence of a co-ordinated sub-national tobacco control programme.

In addition to this, the model allows the user to allocate current smokers to a portfolio of stop smoking interventions. Those included in the model comprise:

- NRT monotherapy;
- NRT combination therapy;
- Pharmacotherapy (Buproprion and Varenicline);
- All of the above with or without behavioural support.

In order to do so, estimates of the effectiveness of smoking cessation interventions and sub-national tobacco control programmes are required. The derivation of these is discussed below.

5. Estimating the effectiveness of tobacco control and stop smoking service investment

There are two primary routes to reducing the avoidable burden of tobacco use: firstly reduce the uptake of tobacco and secondly increase the number of current smokers who successfully quit. Studies have indicated that there exist some very cost-effective interventions to help smokers quit successfully (21,22,17,18,23) and these are often regarded as being amongst the most cost effective uses of health service resources (Table 2).

Stop smoking services can effectively, and cost effectively address individual level needs, however it is important to recognise that they have limited 'reach' and unless commissioned as part of an integrated tobacco control programme will have insufficient impact on wider environmental influences, such as limiting access to tobacco, enforcing smoke-free regulations and ultimately shifting social norms in relation to tobacco to significantly reduce overall smoking prevalence.

A number of discrete tobacco control initiatives have been assessed, including the role of mass media in increasing the quitting rates (24,25) and legislative tools such as smoke free policies (26). The table below summarises some of the economic evidence on tobacco control initiatives.

Table 2: Examples of studies of the effectiveness of tobacco control and stop smoking interventions

Type of intervention	Source	Description
Legislation /regulation		
Legislative smoking bans	(27,28)	Smoking bans aim to protect non-smokers from the harmful effects of exposure to second hand smoke, and offer a supportive environment for people who want to quit smoking. There is evidence that while legislative smoking bans in public places are likely to reduce exposure to second-hand smoke, they have no effect on private cars or homes.
Bans on advertising	(29,30)	No clinical trial exists to show the effect of banning advertisement on uptake of smoking. However, longitudinal studies show that advertising and promotional activities are likely to influence non-smoking young people to take up smoking.
Restrictions on sales to minors	(31)	These include warnings and fines for retailers who illegally make sales to underage youth. There is not a strong evidence as to what extent such restrictions can prevent uptake of smoking among young people.

Social marketing		
Mass media	(24,32,33)	Mass media deliver preventive health messages and have potential to reach and to modify the knowledge, attitudes and behaviour of a large proportion of the community. They may involve communication through various channels, e.g. television, radio, newspapers, posters, etc. There is strong evidence that they can prevent the uptake of smoking in young people and improved quit rates in adult smokers.
Smoking cessation		
Individual focussed	(16)	These are interventions to help smokers to quit and may be delivered by the NHS or at workplace. These may include counselling and nicotine replacement therapy or combination of those. There is clear evidence of effectiveness of these interventions.
Workplace based	(34,35)	Strong evidence exists to show that interventions directed towards individual smokers if delivered at the workplace are likely to increase the number of those making quit attempts and eventually quitting.
Community based	(36)	These include community-wide interventions- "a co-ordinated, multidimensional programme aimed at changing adult smoking behaviour, involving several segments of the community and conducted in a defined geographical area, such as a town, city, county or other administrative district". A combination of mass media and self-help materials can be used and the interventions can be delivered through different channels such as health professionals, volunteers, schools, etc. The evidence of effectiveness of such interventions is limited.

The evidence on these initiatives used in isolation appears to be largely encouraging, suggesting that tobacco control and support to stop smoking are highly cost effective uses of health service resources. However, best practice for affecting behaviour change now points to a multi-component approach, as outlined in the Nuffield ladder (37), included in 'Healthy Lives, Healthy People- a tobacco plan for England' (9).

The effectiveness of these interventions, measured in terms of quitters, is derived from national surveillance data extrapolated to longer-term endpoints where necessary (see Technical Report).

There is also a clear case for local delivery of actions to tackle tobacco. Such actions could include enforcement of a range of tobacco regulations, local community engagement and publicity around tobacco control issues, effective work in schools to reduce uptake. Many localities deliver a suite of activities, coordinated and steered through a local tobacco alliance of key partners. However for the purposes of this report, and looking at published and established methods of measuring the economic impact and return on investment, it has not currently been possible to include disaggregate these types of local tobacco control activity, beyond stop smoking services, in order to reflect them within the model calculations. This by no means detracts from the contribution of wider local tobacco control delivery and indeed other reports, such 'The case for local action on tobacco' published by ASH (38), provide good evidence of key areas for local focus.

In addition to examining services to help smokers quit, the model also allows for an assessment of the impact of a comprehensive, sub-national tobacco control programme. Estimating the effect of sub-national comprehensive tobacco control strategies is challenging. Ultimately tobacco consumption is influenced by a combination of national, sub-national and local strategies and interventions and the degree to which the effect of each can be isolated is limited. Furthermore, sub-national comprehensive tobacco control strategies comprise a number of activities which work synergistically with the ultimate aim of changing social norms around smoking. This complexity means attempts to estimate the impact of such strategies is constrained by the availability of longitudinal data and the degree to which confounding factors can be controlled.

There is an increasing body of evidence to support the case for such programmes, as summarised in a report by the Centre for Disease Control in USA. The state of California was one of the early adopters of a co-ordinated tobacco control programme. This has reduced adult smoking rates from 22.7% in 1988 to 11.9% in 2009, amongst the lowest reported rates in the western world. Lung cancer rates have also declined four times faster in California than the rest of the United States of America (see the accompanying Tobacco Control Report for further details).

In the United Kingdom, the work of FRESH in the North-East has contributed to reducing the smoking prevalence from 29% in 2005 to 21% in 2008 (39). This has brought the prevalence of smoking in the North-East broadly in line with the national average, having traditionally been the region with the highest prevalence (see the accompanying "Tobacco Control Background and Rationale" Report). This has been achieved through a combination of integrated tobacco control delivery including; education and awareness,

health promotion activities and facilitating access to high quality stop smoking services. The approach adopted by FRESH is now being replicated in other parts of the country.

Based on the best available evidence we estimate that the presence of a sub-national tobacco control strategy can increase the background quit rate from 2% to 5% (see Technical Annex at the end of this Report for full derivation of this figure). This occurs through a combination of effects which include increasing the number of individuals motivated to quit, increasing the number who make quit attempts and increasing the number who make successful quit attempts. The model captures the increase in the number of current smokers who access Stop Smoking Services as the result of sub-national programmes through this new background quit rate. The evidence base as to the effect of sub-national programmes on the uptake of Stop Smoking Services is not sufficiently robust to model it otherwise.

It is recognised that this estimate is subject to significant uncertainty but is believed to represent the best available estimate of the quit rate. Furthermore, this assumption was reviewed at a meeting of tobacco control experts who concurred that in the absence of definitive evidence this was a plausible assumption for the purposes of this research.

6. Estimating savings from Tobacco Control programmes: Illustrative Case Study from the North West of England

The model was run for the North-West population which, according to the latest estimates, has a smoking prevalence of 23.2%. Three scenarios were considered:

Scenario 1: No local tobacco control services are provided and there is no sub-national programme in place;
Scenario 2: Local tobacco control services are provided and there is no sub-national programme in place;
Scenario 3: Local tobacco control services are provided supplemented by a sub-national programme.

For the purposes of this illustrative analysis, we assumed that 10% of smokers present for NHS Stop Smoking Services (local tobacco control programmes) and are allocated to a combination of NRT and pharmacotherapy supported by behavioural support.

Example outputs from the three scenarios are presented below.

Example of the impact of tobacco in the North West of England: cumulative outcomes over 2 years

	Scenario 1	Scenario 2	Scenario 3	Scenario 2 savings	Scenario 3 savings
GP consultations (£)	£111,932,731	£109,967,251	£105,745,371	**£1,965,480**	**£6,187,360**
Hospital admissions (£)	£219,464,160	£218,198,679	£215,406,815	**£1,265,481**	**£4,057,344**
Quitters (number)	49,025	71,836	133,332		
New smokers (number)	97,928	96,196	92,543		
Productivity loss (£)	£197,483,109	£194,025,261	£186,533,893	**£3,457,848**	**£10,949,215**

The short-term findings suggest that the combination of local stop smoking services coupled with a sub-nationally co-ordinated tobacco control programme generate significant savings in the volume of healthcare consumed, significantly increase the number of quitters whilst reducing the number of new smokers and also reduce lost productivity associated with smoking attributable illnesses.

With a smoking prevalence of 23.2% and an adult population of 5,601,000, North West has an estimated smoking population of 1,299,432. Without local stop smoking services or a sub-national tobacco control programme in place (Scenario 1), the model estimates that smoking will cost North West approximately: £722m over the next 2 years (incl. £517m in costs to the NHS) and £1.24bn over the next 10 years. By establishing local stop smoking services in North West (Scenario 2), the model estimates the following

savings to society: £13.5m over the next 2 years (incl. £6.48m in savings to the NHS) and £9.65m over the next 10 years. By establishing a sub-national tobacco control programme in North West to work alongside local stop smoking services (Scenario 3), the model estimates the following savings to society: £42.8m over the next 2 years (incl. £20.5m in savings to the NHS) and £166m over the next 10 years

The introduction of a comprehensive sub-national tobacco control programme in combination with effective local services to help smokers quit (moving from Scenario 2 to Scenario 3) is estimated to generate almost £14 million (not shown in the above Table) in savings for the health service alone in the first two years. The savings to the broader economy include a further £8 million in productivity losses avoided due to reduction in smoking.

Clearly, many of the effects of reducing exposure to tobacco are only likely to manifest themselves in the longer term. Looking over a ten year time horizon, introducing a sub-national co-ordinated tobacco control programme to supplement local provision (i.e. moving from scenario 2 to scenario 3) is expected to reduce the number of lung cancer cases by more than 600, the number of CHD cases by around 17,000, the number of COPD cases by around 3,500; number of myocardial infarctions by 7,300 and the number of strokes by more than 4,300. The additional number of quitters over ten years as a result of a sub-national tobacco control programme is estimated to be in excess of 22,000. Adopting a lifetime perspective, the introduction of the sub-national tobacco control programme is expected to result in approximately 3,500 fewer deaths attributable to smoking related illnesses.

The illustrative findings based on the North-West population presented above make a striking case for supplementing local delivery with a sub-national tobacco control programme. The findings suggest that there is a symbiotic relationship between local delivery of stop smoking services and sub-national co-ordination of tobacco control activities. Furthermore, the findings suggest that whilst many of the health effects of tobacco control only become apparent in the longer term, significant savings can be made in the short-term which can at least partially offset the costs associated with running a sub-national programme.

7. Conclusions and Recommendations

Tobacco use is associated with a net cost to society due to the adverse effects it has on health and the economy more broadly.

International evidence suggests that national legislative frameworks reinforced at sub-national levels with substantial broad-based tobacco control programmes including evidence-based commissioning of locally-coordinated stop smoking services can yield the best outcomes. The presence of a sub-national programme which is geared towards co-ordination to optimise the benefit from both national policy and local delivery and helps to present a consistent message about the harms of smoking through effective media campaigning in particular is well established. Ultimately, the ambition of such programmes is to expedite social norm change in relation to tobacco, so that tobacco becomes less desirable, less accessible and less accepted.

Our analyses suggest that supplementing local delivery with a sub-national tobacco control programme can result in significant incremental benefits in terms of improved health outcomes, avoidance of disease and reduced economic burden to society. These effects occur as tobacco control can reduce the uptake of new smokers – 'turning off the tap' – and also support more current smokers to quit.

Our analysis suggests that this can result is sizeable financial savings for the health sector as well as the local economy and that whilst many of the health effects may only occur some way into the future, the financial savings start to occur almost immediately.

As with any research, it is important that the limitations of the analysis are discussed transparently. There are two major drivers of our analysis: the background quit rate and the effective of tobacco control programmes on this rate. In both cases, we have made an informed assumption about these parameters, using the best available evidence, but both parameters remain the subject of uncertainty. In order to address this, we have designed the modelling element of the toolkit to allow these parameters to be easily changed to reflect differences in rates between regions or emerging evidence.

A further limitation of our analysis is that it only partially captures the effects of tobacco. The health effects are limited to a number of conditions known to be attributable to smoking but a significant number of other conditions were excluded, either to simplify the model or due to data constraints. Similarly, some of the broader societal effects were also excluded from the model (such as the financial costs of fires) due to data constraints. As a result, it is likely that we are under-estimating the costs associated with tobacco use.

In spite of these limitations, it is hoped that the model and the accompanying materials are a useful resource for commissioners, planners and those involved in the delivery of tobacco control programmes. The tool has been designed with commissioners in mind and allows for bespoke analyses of local data and generates evidence that is expected to be relevant to health and local authorities. More complex approaches to modelling the effects of tobacco were considered but the research team remained cognisant of the need to balance robustness with pragmatism and practicality. The resulting model has a rapid run time and allows users to easily undertake 'what-if' analyses which would not have been available if a more complex modelling approach had been adopted.

The current model is made available in Microsoft Excel, a package which is readily available and widely used amongst commissioners. Consideration is being given to whether a web-based interface might be more appropriate and facilitate more widespread use of the tool.

8. Technical annex

The broader impacts of tobacco

Our analysis attempts to generate estimates of the financial impact of tobacco which can be adapted for use within a local health economy. A number of previous studies have sought to capture the economic impacts of tobacco, although it is fair to say that he majority of the evidence relevant to the United Kingdom considers the impacts at a national level. Attempting to systematically summarise this evidence was beyond the scope of this project although a number of key studies were considered in the early stages of the research to assist in the design of the model.

The vast majority of the evidence identified focuses on the negative health effects of smoking and, to a lesser extent, the costs associated with managing these effects. However, there is also a reasonable body of evidence examining what we refer to as the 'non-health' effects, or broader financial impacts on society. A number of previous studies that have sought to estimate the financial impact of tobacco use have adopted a perspective which captures some of these societal costs, such as productivity losses and fires. Furthermore, some analyses have also sought to take into account the health and non-health effects of passive smoking.

Examples of studies covering a range of health and non-health impacts reviewed as part of this research are presented in the table below.

Table A1: Types of 'health' impacts of tobacco

Impact	Indicator	What it measures	Example of studies/sources
Loss of life	Number of life lost	Smoking-attributable mortality. This is the total number of lives lost due to tobacco use.	(1)
	Years of life lost	This is the number of years lost due to premature mortality attributed to smoking. Mortality occurring in younger ages will lead to more years lost.	(1,40)
	Quality (disability) adjusted life years lost	This adjusts the years of life lost by quality of life, assuming that years lived in a morbid condition may not be the same as years lived in health.	(1)
Health and social care costs	Costs to NHS	These are the costs such as primary care visits, hospitalisation, ambulances, pharmaceuticals, etc. that arise due to treating conditions caused by tobacco use.	(1,11,12,40)
	Costs to social services	This includes costs of personal social care services (e.g. institutional care) arising due to meeting needs caused by tobacco use	(41)

Table A2: Types of 'non-health' impacts of tobacco

Impact	Indicator	What it measures	Example of studies/sources
Business costs	Productivity losses	These are the losses in paid workforce due to reduced workforce size, increased absenteeism/ presenteeism, reduced on-the-job productivity including smoking breaks	(13,14,41-43)
	Employment losses	This is the impact of reducing the size of smokers. Less tobacco consumption may mean less employment in tobacco and associated industries	(13,14,41,42)
Household costs	Productivity losses	These are the costs of unpaid activities that could have been replaced by market goods and services	(41)
	Expenditure on tobacco products	Usually measured as % of household budget spent on tobacco, this represents the burden of tobacco on household income	(41)
Public services costs	Smoking attributable fires	Fires caused by smoking materials and matches. May include household or commercial fire damage as a direct result of careless smoking habits	(44)
	Litter management costs	This includes the costs of cleaning used tobacco products, including cigarette butts.	(41)
	Sickness and incapacity benefits	These are the benefit payments to those suffering from diseases caused by smoking. This also includes pension and other benefit payments to families of those who die as a result of their smoking	(41)
	Budgetary impact	This is the impact on government revenue of increasing taxes and duties on tobacco products to encourage less tobacco consumption	(15,45)

Table A3: Passive smoking as an impact of tobacco

Impact	Indicator	What it measures	Example of studies/sources
Health impact	Loss of life and health/social care costs	These include all health impacts described in Table 1, but as a result of second hand smoke	(10)
Non-health impact	Costs to business, households and public services	These include all non-health impacts described in Table 2, but as a result of second hand smoke	(46,47)

Our current study has similarities to previously published research in as much as it adopts a partial societal perspective; that is it considers some of the societal impacts of tobacco but notably excludes others. For example, we were unable to include the costs associated with smoking related fires and litter in our analysis, due to the limited evidence base on this topic and the approach we chose to adopt which lends itself more naturally to considering the health impacts of tobacco, which remain the primary consideration of many commissioners and policy makers. Furthermore, we have made no attempt to consider the macro-economic/industrial implications of smoking, unlike say Reed 2007 (45). Whilst these may be of interest to national policy makers and in particular the exchequer, these were deemed to have little relevance to the commissioning audience that we were seeking to inform.

Whilst our analysis builds on previous studies and attempts to address some of their limitations, we too were limited by the need to develop a model that was sufficiently flexible and pragmatic for use by commissioners who expressed a strong desire to undertake real time analyses.

Derivation of hospital admissions associated with tobacco related illnesses

A number of previous analyses have considered the impact of tobacco on hospital admissions. The most frequently used method to do so is the use of attributable fractions which approximate the proportion of all admissions for a particularly illness which might be considered to be smoking related.

The steps involved in this approach are as below:

1. Identify smoking related conditions of interest (e.g. COPD, lung cancer etc);
2. Identify the types of admissions to be included in the analysis (in-patient, out-patient, day-case, emergency admissions etc);
3. Identify relevant the number of admissions for each condition;
4. Apply the proportion of admissions attributable to smoking;

5. Apply unit costs to each admission;
6. Derive total number of admissions and their associated cost.

This might be considered as a 'top-down' approach; it starts by considering aggregated, national data on hospital admissions and allocates these to particular causes.

This seemingly simple process is thwarted by complexity throughout. First is the choice of smoking attributable conditions to be included in the analysis. Whilst there is a clear association between some conditions and tobacco use (lung cancer), the evidence of association with others may be less well defined (e.g. endometrial cancer). Previous analyses that have sought to estimate the financial burden of smoking have considered a significant number of smoking attributable conditions, as presented in the table below, although it should be noted that there are some notable differences in conditions considered to be associated with smoking.

Table A4: A comparison of three main UK studies in their choice of model ingredients

Disease conditions	**ICD-10**	**Callum and White 2004** (48)	**Callum et al. 2010** (11)	**LHO 2010** (49)
Lung	C33-C34	√	√	√
Lip, oral cavity & pharynx	C00-C14	√	√	√
Larynx	C32	√	√	√
Oesophagus	C15	√	√	√
Bladder	C67	√	√	√
Kidney	C64-66,C68	√	√	√ minus C66
Stomach	C16	√	√	√
Pancreas	C25	√	√	√
Myeloid Leukaemia	C92	√	√	√
Cervix	C53	X	√	√
Unspecified site	C80	√	√	X
Chronic Obstructive Pulmonary Disease	J40-J44	√	√	√
Pneumonia	J10-J18	√	√	√
	I00-I09			
Ischaemic/Coronary Heart Disease	I20-25	√	√	√
Pulmonary heart disease	I26-I28	X	√	√
Other heart disease	I30-I51	Only I51	√	√
Cerebrovascular Disease / Stroke	I60-I69	√	√	√
Aortic Aneurysm	I71	√	√	√
Atherosclerosis	170	√	√	√
Other arterial disease	I72-I78[1]	X	√	√

Ulcer of Stomach+Duodenum	K25-K27	√	√	X
Parkinson's disease*	G20	G20-G21	√	X
Endometrial cancer (smokers)*	C54	√	**X**	X
Peripheral vascular disease	I73.9	√	√	X
Crohn's disease	K50	√	√	X
Periodontitis	K05	√	√	X
Age-related cataract (45+)	H25	√	√	X
Hip fracture	S72	√	√	X
Ulcerative colitis*	K51	√	√	X
Uterine fibroids – women*	D25	√	√	X
Spontaneous abortion	O03	√	√	X
Excessive vomiting in pregnancy*	O21	√	√	X
Gestational pre-eclampsia*	O14	√	√	X

*protective effects of smoking

The second complication in this process is the estimation of the attributable fraction to be applied to the number of admissions. The attributable fraction is the proportion of admissions for a particular condition (e.g. lung cancer) that can be attributed to a single cause (in this case, tobacco use). There are numerous studies which include the derivation of smoking attributable fractions within a given population, usually derived from analysis of longitudinal datasets. In economic evaluations, these attributable fractions are then applied to healthcare resources (most commonly hospitalisations) to estimate the volume of resources consumed that might be attributable to smoking. The smoking attributable risk factor for any condition can be regarded as a moving target as it is a function of the prevalence of smoking and the condition under consideration. Estimating the attributable risk factor usually requires a longitudinal data series and as such, risk factors are a reflection of historic data. The result is that risk factors for behaviours which are decreasing over time (such as tobacco use) may overestimate the attributable fraction. Furthermore, the smoking attributable fraction is typically derived from evidence on the relative risk of developing a condition depending on smoking status and is then applied to resources. This assumes that resource use is correlated with morbidity. For example, if 40% of COPD cases are attributable to smoking then 40% of the resources consumed in managing COPD are also attributable to smoking. In most instances, this relationship is poorly understood and it could be that the attributable proportion of resources used is higher or lower than the attributable morbidity. Finally, there is concern that the use of attributable risks is subject to some significant uncertainty, particularly in conditions where there are multiple risk factors. For example, it is possible that summing the attributable fractions for risk factors of heart disease produces a figure greater than 1 (50). This suggests that there are interactions between the risk factors which are not fully understood.

The final steps in the attributable fraction approach include the estimation of resources used to treat smoking related morbidities and their costs. Whilst there are readily available sources of evidence on the number of admissions to secondary care in the NHS (Hospital Episode Statistics) these are known to be imperfect due

to inconsistencies in coding at a local level, thus introducing further uncertainty into the estimate of resource use. Similarly, estimates of prescriptions and GP consultations are also subject to some uncertainty and there are a number of alternative approaches to estimating the unit costs associated with admissions.

This seemingly simple arithmetic can actually result in quite divergent estimated of the number of admissions and their cost as a result of employing different assumptions throughout.

An alternative 'bottom-up' approach

Previous analyses which have sought to capture both the costs and health effects of smoking have adopted an alternative, 'bottom-up' approach to estimating smoking attributable resource use. This is due to both limitations in the evidence base on the association between tobacco use and the incidence of disease as well as computational complexities.

Many of the economic analyses of smoking have adopted a cohort approach whereby a cohort of smokers is followed over time and the effect of their smoking behaviours are modelled, taking into account the effect of tobacco use on healthcare resource use and health outcomes. These analyses often adopt a lifetime perspective, seeking to estimate the incidence of disease over time and the costs of managing smoking attributable illness. In many cases, the models estimate the incidence of smoking attributable illnesses and then allocate a crude, annual or lifetime cost to these conditions. In these instances, the models report the cost of smoking attributable illnesses but at an aggregate level which does not allow for reporting of the use of individual healthcare resources (e.g. hospitalisations, GP visits, prescriptions etc). This is recognised as a limitation of these models.

A more nuanced version of this approach is to identify differences in healthcare resource use amongst smokers, former smokers and non-smokers to estimate the excess resource use amongst the former groups. This allows the analysis to report resource use in a more granular fashion (e.g. hospitalisations, GP visits etc) and apply costs to these resources in a disaggregated fashion. By doing so, users of the analyses can better identify where and when costs are incurred.

For example, in our analysis the risk of hospitalisation (all cause) was derived from self-reported survey data which reported the rates of hospitalisation (in-patient) by smoking status. By controlling for other demographic and health characteristics we were able to estimate the relationship between smoking status and hospitalisations. The benefit of this approach is that it provides more granular estimates of resource use than in some previous analyses. The disadvantage is that it estimates excess healthcare resource use in totality, rather than by cause (i.e. total excess hospitalisations, rather than excess hospitalisations for COPD or lung cancer). Furthermore, the reliance on self-reporting creates some concerns about under (or over)—reporting or healthcare resource use.

Each approach has their relative merits and neither can claim to have a high degree of accuracy when used to estimate resource use. It is likely that attributable fractions might over-estimate resource use due to difficulties in controlling for interactions between risk factors. The bottom-up approach on the other hand is likely to under-report the true costs due to under—reporting or inaccuracies in self-reporting.

Approach adopted in the current analysis

Consistent with similar previous analyses, our analysis initially adopted a bottom-up approach to estimating resource use. That is, we estimated excess healthcare resource use amongst smokers and non-smokers and applied this to a cohort of smokers who were followed over time. In line with similar analyses, we chose to focus on only a small number of smoking attributable conditions where the association between smoking and disease outcomes was considered to be well established. These comprised COPD, lung cancer, stroke and coronary heart disease.

Having initially adopted this method it became apparent that our approach was generating rates of hospitalisation far below those of previous analyses which had adopted an attributable fraction approach. This could be partially explained by the limited number of smoking attributable conditions that we chose to include in the analysis compared to earlier studies. A further explanation may be the choice of hospitalisations included in our analysis (in-patient) compared to previous analyses. However, it was felt that even combined these two factors did not fully explain the magnitude of the difference to previous analyses.

The most likely cause of the differences to previous studies was believed to result from the use of self-reported survey data which is expected to result in inaccuracies and possible under-reporting of hospitalisations. Under-reporting may occur partly as a result of recall bias (forgetfulness) as well sample bias. For example, household surveys are unlikely to elicit responses from individuals who are particularly sick and as such, the reported rates of hospitalisation are unlikely to be a true reflection of national resource use.

Given the importance of benchmarking our outputs against previous analyses, we chose to adapt an attributable fraction approach to estimating hospitalisations in the short-term amongst smokers. Attributable fractions are, at least partly, dependent on the prevalence of smokers. The prevalence in our model is dependent on the characteristics of the population at year 0 and then changes over time depending on the tobacco control interventions which are adopted. A falling prevalence over time will reduce the number of admissions by reducing the attributable fraction. The major simplifying assumption in this analysis is that the total number of hospital admissions remains constant over time. However, given that our analysis only reports admissions over the short-term (a two year timeframe) this is a reasonable assumption.

The result is a model which predicts the number of admissions for a selection of smoking attributable conditions which are broadly consistent with previous analyses. This was seen to be an important policy message as adoption of the novel method would have resulted in some significant disparities with previous

analyses. Furthermore, this approach is also consistent with a number of studies of other public health challenges, such as alcohol abuse and drug use. However, it is worth considering whether perpetuation of the attributable fraction approach is desirable and further examination of the alternative approaches to this is recommended.

In conclusion, it appears that relying on a bottom-up approach, reliant on self-reported rates of admission, is likely to lead to some degree of under-estimation of resource use whilst a top-down approach, reliant on attributable fractions, is likely to lead to an over-estimate of resource use. In reality, the number of smoking attributable admissions is likely to be somewhere in the middle and further research on this is warranted if it can result in methods which are applicable not only to smoking but also other health behaviours.

Top-down Statistical Attributable Fraction (SAF)

This is a disease-based approach and has been used widely (11,48,49). In this method, statistical attributable fractions (SAF) are calculated first for each disease that has causal relationship with smoking.

Technically,

$$SAF= [P_{cur}(R_{cur}-1)+P_{ex}(R_{ex}-1)]/[1+ P_{cur}(R_{cur}-1)+P_{ex}(R_{ex}-1)]$$

Where,

P_{cur} = prevalence of current smokers;
P_{ex} = prevalence of former smokers
R_{cur} = risk of healthcare resource use among smokers relative to never-smokers
R_{ex} = risk of healthcare resource use among former smokers relative to never-smokers

This formula gives a proportion that will then be applied to total numbers of hospital admissions by selected disease conditions in order to produce the number of admissions that can be attributable to smoking. If SAF=0.75 for lung cancer, for instance, and there are 1000 admissions in the last year that were ICD coded as C33- C34 (neoplasm of trachea, lung and bronchus), the number of smoking attributable admissions would equal to 750. Multiplied with appropriate HRG-based reference cost will then yield smoking attributable costs of those admissions.

The disease conditions that are caused by smoking or where smoking can have protective effects were identified by a review of literature (Table A4). We used the relative risks estimates from the Smoking-Attributable Mortality, Morbidity, and Economic Costs, SAMMEC (51). These figures are based on systematic review of literature and are estimated primarily to apportion smoking attributable mortality. Recent studies have extended the use of these figures to estimate SAFs for hospital admissions too (49). However, SAMMEC's relative risks estimates are available for a few disease conditions only. Based on a narrative

review of the literature, Callum et al. 2010 (11) provide relative risks for other disease conditions that are caused by smoking or where smoking has a protective effect. In order to include wider range of disease conditions, we sourced relative risks from both studies.

The next step was to identify age- and gender-specific hospital admissions by the selected disease conditions. This was sourced from Hospital Episode Statistics. A three year mean (from 2006/7 to 2008/9) was taken in an attempt to capture annual changes in events. The economic model predicted the number of smokers and former smokers in year 1 and year 2. These figures were linked back to the overall population to estimate prevalence of smokers and former smokers in years 1 and 2. Combing the relative risks with this prevalence, we estimated age- and gender-specific SAFs using the above formula by all the diseases in each year. These proportions were then applied to the relevant total number of admissions to yield smoking attributable admissions by the selected diseases over two years. In order to translate the numbers of smoking attributable admissions to costs, appropriate unit costs were needed.

Unfortunately, there is no direct mapping between the most recent HRG4-based reference costs and ICD-10 codes by which the number of hospital admissions were identified in the HES data. Following Callum et al. 2010 (11), who also encountered the same problem, we used 2005 HRG3.5 based reference costs and inflated them to represent the year 2009/10 although this entailed the assumption that the distribution of inflation-adjusted reference costs remained static over time. The unit cost for each disease was estimated as the weighted average of elective and non-elective admission costs for relevant procedures as indicated by ICD-10 to HRG3.5 mapping (52), the weights being the number of activities within those procedures.

Model specification

In the early stages of the research we identified a number of analyses which considered the financial impact of tobacco, either as an endpoint in itself or as integral part of an economic evaluation of smoking cessation interventions.

The studies can be categorised loosely into three categories:

- Economic evaluations of smoking cessation interventions, which report estimates of the financial impact of tobacco in order to estimate the cost effectiveness;
- Studies where the endpoint is in itself an estimate of the financial impact of tobacco;
- Studies which consider some of the macro-economic effects of tobacco and policies intended to affect them (e.g. taxation).

Table A5: 'Group I' economic models of tobacco relevant to UK context

Model type	Source	Purpose of the model	Modelling approach[1]
Smoking cessation interventions	(16)	It determined the cost effectiveness of smoking cessation interventions delivered in the workplace, by the NHS and by the mass media	Markov modelling- 6-monthly cycle; 5 distinct co-morbidities (lung cancer, CHD, COPD, MI and stroke)
Business costs (productivity losses)	(14)	Detailed the cost of smoking to UK businesses in total and since the smoke free workplace legislation has come into effect	Population attributable fraction method
	(53)	Illustrated potential gains from smoking cessation provision by estimating the costs to employers of smoking	Excess sickness absence method
Health care costs of smoking	(12)	Health care costs due to smoking. Considered cancer, respiratory illnesses, circulatory illnesses and digestive disorders as the key outcomes	Two methods used: attributable fraction and comparing costs of smokers and non-smokers
	(1)	Estimated the direct costs to the NHS of treating illnesses caused by smoking.	Attributable fractions
	(1)	Estimated mortality, years of life lost and years of life lost in disability together with NHS costs attributable to smoking	Attributable fraction
Increasing tobacco taxation	(45)	Estimated the impact of increasing the level of taxation on tobacco products.	Two methods: a cost-benefit analysis of wider effects on the economy and a public finance analysis
Income and cost of smoking	(15)	Estimated the tobacco income and compared this with the costs of smoking in society	No modelling used. Compiled data from various sources.
Passive smoking in children	(26)	Estimated mortality and morbidity impacts of passive smoking in children and associated health care costs	Attributable fraction
Impact of smoking	(54)	It attempted to identify optimum strategies that will be needed to reduce smoking prevalence.	Attributable fraction
Smoking attributable costs of admissions	(49)	Estimated smoking attributable costs of admissions per 100,000 populations. Also provided granularity in presentation by having such estimates available for the whole of England, for the regional levels and for LA and PCT levels.	Attributable fraction

[1]Note: Markov modelling is a mathematical technique in which individuals are assumed to have been in a particular state and then they can move from this state to a new state with some transitional probability. For example, we can assume that there are some smokers (a state) initially in our population but some will quit and become former smokers (a new state) or die (another state). This construct helps to predict the consequences of smoking over time. In the population attributable fraction method, however, a share of total observed events that could be attributed to tobacco are estimated with the help of relative risks and smoking profile. For example, 22% of all meningitis admissions in children 0-14 in England are attributable to passive smoke exposure (Ref: RCP). In excess sickness models, it is assumed that the excess events observed in the standardised groups of smokers and non-smokers are due to smoking.

Our intention was to build on previous research wherever possible whilst also addressing some of the recognised shortcomings of previous studies. In order to better understand user needs, we started the research by conducting interviews with a range of stakeholders, including commissioners from health and local authorities to understand what information they would wish to see in a model intended to inform tobacco control commissioning decisions. This highlighted important characteristics that needed to be inherent in the model, including:

1. Balancing robustness with transparency and ease of use, and in particular ensuring that the model had a short-run time to allow for 'what-if' analyses to be conducted
2. The need to show short-, medium-, and long-term health impacts and costs associated with tobacco use;
3. The need to report the health and non-health impacts (e.g. broader societal impacts such as productivity losses) of smoking;
4. The need to capture new smokers and passive smokers.

On reflection, we chose to develop a Markov model, building on the approach originally developed by Flack et al. 2007 (16). This approach considers a cohort of individuals and categorises them as current smokers, former smokers or never smokers. The individuals are then modelled over time to determine how their smoking status might change.

The Markov modelling approach lends itself to the analysis of conditions/populations which can be neatly categorised, for example by smoking status. This approach also allows for the assessment of short, medium and long-term outcomes by considering the status of the cohort at different time points (for the purposes of our analysis, 2 years, 10 years and lifetime) and any events and associated costs at these time points.

However, it is important to acknowledge that Markov models have their limitations. Categorising individuals into discrete states means that such models may be insensitive to changes in risk within categories. For example, within our model an individual who smokes 100 cigarettes per day has the same risk of developing tobacco related conditions as an individual who smokes 1 cigarette per day. A further limitation of Markov models is that they do not have the capacity to handle an individual's history so event rates are typically independent over time. Clearly in practice, individuals who have a prior history of a cardiovascular event have a higher risk of future events but this is not incorporated into our analysis.

It is important to recognise that the current approach attempts to balance pragmatism with robustness. Whilst a more complex, simulation modelling approach would allow some of these issues to be addressed, the run time associated with such models means that they are unlikely to be suitable for a commissioning audience that wants to run real-time analyses. Furthermore, it needs to be acknowledged that all models are an imperfect representation of the real world. Often, as a model attempts to replicate the real-world more closely the level of data required to populate the model increases significantly. Thus, further pragmatism is required to balance the modelling approach with the available evidence base.

As such, we consider the Markov modelling approach to be 'fit-for-purpose' in this setting and would emphasise that similar approaches have been used to inform national guidance issued by NICE as corroboration of our approach.

Estimating the health impacts of smoking

The model considers three different scenarios (short, medium and long term), and therefore, different outcomes are considered according to the specific scenario.

The short term scenario included primary and secondary care. GP and practice nurse consultations, outpatient attendances and prescriptions were included in primary care. The secondary care comprised of hospital admissions, mainly due to cancer, cardiovascular disease, respiratory and other admissions. The number of people with a condition is calculated by multiplying the number of smokers or former smokers at a particular point in time in the model by the prevalence of those diseases for each of this population groups according to their smoking profile. The total number of cases is the average across the time period modelled.

The number of adults and children exposed to smoking (passive smokers) is calculated by multiplying the number of smokers by the average proportion of adults and children exposed to passive smoking generated by an adult smoker derived from the Health Survey for England data. The number of quitters and new smokers are also estimated. The total number of quitters results from multiplying the number of smokers by the quit rate in that particular time period.

In the medium term scenario, the counts and costs of smoking related conditions (lung cancer, coronary heart disease, chronic obstructive pulmonary disease, myocardial infarction, and stroke cases); total number of quitters; and productivity losses measured through work days lost are estimated. These numbers are obtained with the same process as described before.

Long term outcomes (lifetime) focused on mortality profile (number of deaths and life years), treatment costs and quality of life years (QALYs). The number of people dying from all-cause mortality is obtained directly from the Markov model. The life years results from the total number of people with different smoking profile multiplied by the time period used in the model for each particular cycle. Deaths are subtracted from the total number of people in the model. Treatments costs results from the total number of people with a particular disease (i.e. myocardial infarction) by the total cost of treating a patient with a particular disease episode (i.e. myocardial infarction). The QALYs calculation adjusts the life years of each cycle by the quality of life weight attributed to each particular health state of the different population groups included in the model.

Estimating the effects of smoking cessation and tobacco control interventions

In the absence of robust long-term effectiveness data (annual cessation rates) on Stop Smoking Services , we, after preliminary reviews and expert consultations, extrapolated 52-week effectiveness of eight interventions (mono NRT, combo NRT, Bupropion and Varenicline, each with and without behavioural support) from available 4-week observed effectiveness data from various Cochrane databases of systematic reviews as reported in a Department of Health document (55) . This was achieved as follows:

Step 1: Obtain the most relevant effectiveness data for NHS Stop Smoking Services

The following Table provides 4-week quit rates in the NHS Stop smoking services (55). These are observed rates.

Table A6: Observed 4-week quit rates in NHS Stop Smoking Services

Four-week quit rates	No medication	Mono NRT	Combo NRT	Bupropion	Varenicline
No support	16%	25%	36%	28%	37%
Individual behavioural support	22%	37%	50%	39%	52%
Closed Group behavioural support	32%	50%	71%	55%	74%

Step 2: Discount these rates with reasonable rates to reflect a 52-week quit rate

The most plausible and robust data on relapse came from a HTA systematic review from Coleman et al 2010 (56). Following this, we calculated the net difference (reduction) between 4-week and 52-week smoking prevalence rates (Table A7). For example, the smoking prevalence rate at 4-week with mono NRT is 50.32% whereas at 52-week it is 29.28%. Therefore, the net reduction in prevalence is: 21.04%.

Table A7: Relapse from 4-week to 52-week based on Coleman et al. 2010 (56)

	No medication	Mono NRT	Combo NRT	Bupropion	Varenicline
Relapse rate		21.04%	22.8%	15.36%	17.1%

Thus, subtracting rates in Table A7 from those in Table A6 will give ‘extrapolated’ 52-week quit-rates for the NHS Stop Smoking Services (Table A8). The lowest estimates from individual or closed group behavioural support were used as conservative estimates.

Table A8 'Extrapolated' annual quit rates for local cessation intervention

Annual quit rates	No medication	Mono NRT	Combo NRT	Bupropion	Varenicline
No support	2%	3.96%	13.2%	12.64%	19.9%
Individual behavioural support		15.96%	27.2%	23.64%	34.9%
Closed Group behavioural support		28.96%	48.2%	39.64%	56.9%

Estimating the background quit rate

Firstly, to consider the effect of any tobacco control or smoking cessation strategy, it is necessary to calculate their incremental effectiveness, i.e. the number of additional smokers who might quit when exposed to the intervention. This acknowledges that some smokers may choose to stop smoking through a combination of education, self-motivation and national tobacco control initiatives. This effectiveness is often referred to as the "background quit rate". A number of previous analyses have sought to establish this 'background quit rate' amongst smokers.

Table A9 provides a summary of the rates adopted in recent analyses. Many of these analyses, particularly more recent studies, point to the work being carried out under Smoking Toolkit Study (20) that has analysed national prevalence data and quit rates over time. The findings suggest that quit rates over the last 40 years have typically been between 1-2% per annum, although more recent estimates (from 2006) suggest that the quit rate has increased to between 2-3%.

Table A9: 'Background quit rates' used in previous economic analyses

Source	Background quit rate adopted
Coleman et al 2010 (56)	2% (varied in sensitivity analysis)
Flack et al 2007 (16)	2% (varied to 1.2% in sensitivity analysis)
Parrott et al 2006 (18)	2% (varied in sensitivity analysis from 1-4%)
Woollcott et al 2002 (17)	1%

In the presence of a national strategy only, it is thus reasonable to assume the background quit rate to be 2%, in line with the above studies. This background quit rate is known to change over time and anecdotal evidence suggests that quit attempts and the rate of successful quitting has fallen over the course of the

recent recession and might be expected to fall further if national funding for tobacco control and smoking cessation is reduced due to cuts in public health expenditures.

The second important consideration to answer the above question as to how local decision-makers work out the internal rate of return of their investment decisions is the background quit rate under regional programmes. As no obvious evidence exist at this end, it is important to understand what actually constitutes regional programmes. Based on international (e.g. the World Health Organisation's MPOWER model and the Californian Tobacco Control Programme) and domestic (e.g. FRESH North East) experience, we define, for the purpose of this report and accompanying economic tool, regional programmes as:

> *"Regional programmes are activities which are implemented and/or coordinated by Regional Authorities under Regional Tobacco Policy 2005 and have potential to affect the entire population including those who want to quit and who are passive smokers. This may include monitoring and enforcement of national legislations (e.g. smoke free, illicit tobacco sales, advertising bans), taking responsibilities for paid and unpaid mass media, evaluation and monitoring progress of control programme and advocacy work to influence national and possibly international actions. Regional programmes do not provide cessation services directly (cessation services are local interventions) but play supportive roles on this".*

It is clear from the above definition that regional programmes influence population attitude towards tobacco. This is assumed to lead to more people making quit attempts which may result in more successful quitters. As smoking prevalence falls due to the increased number of successful quitters in the presence of regional programmes over time, they (the regional programmes) will have positive impact on passive smoking and uptake of smoking as well. So, regional programmes are wider tobacco control initiatives, not the kind of tobacco control programmes which are limited to smoking cessation services only.

The evidence on the effect of co-ordinated regional programmes from the United Kingdom is limited. Some early evidence from the North-East's FRESH programme is available which shows that smoking prevalence has fallen from 29% in 2005, the year the FRESH programme was launched, to 21% in 2008, an annual quit rate in excess of 5% (39). This compares with national estimates which show a reduction of 3% over the same time period (from 24% to 21%). Further evidence from international evaluations, e.g. the Californian Tobacco Control Programme, suggests that 13% of current smokers quit with a workplace and household smoking ban as a result of 55% making quit attempts – a drop of 11% in smoking prevalence over 20 years (57,58).

Thus, there is no definitive estimate of the background quit rate under regional programmes. Indeed, the variation in what comprises a regional strategy and socio-cultural differences make any attempts to generalise estimates of effectiveness unwise.

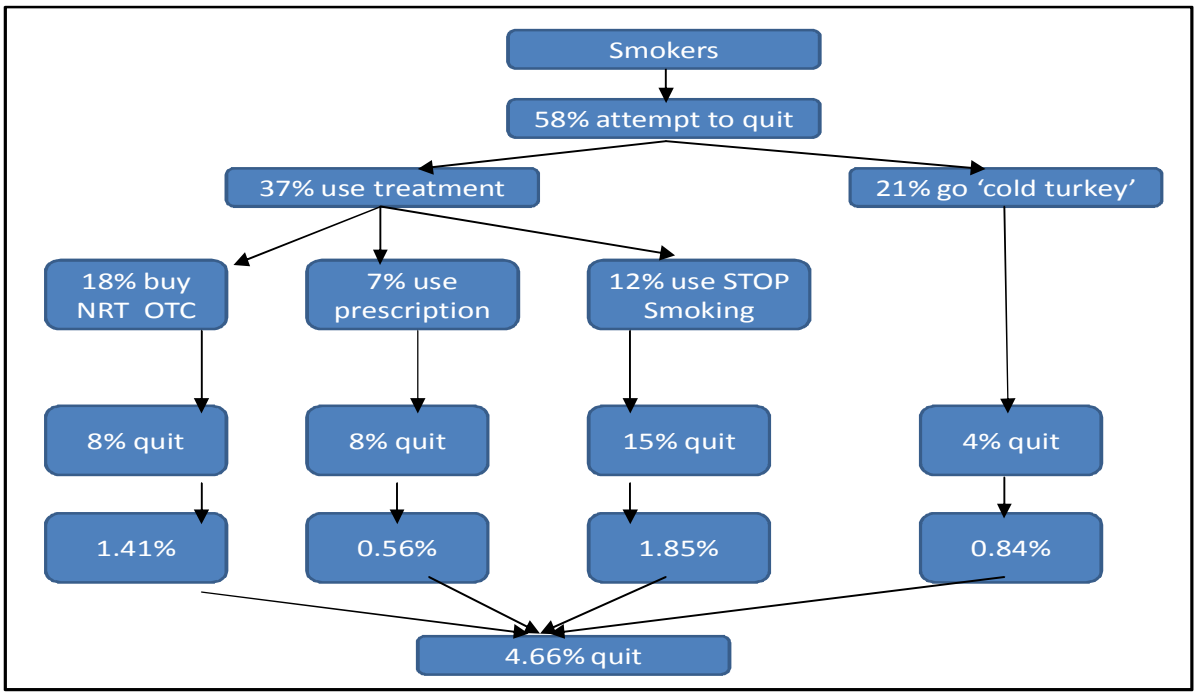
In this report, we attempt to estimate 'likely' background quit rates under regional programmes based on two considerations: (a) effectiveness of legislative tools and mass media, as they are main drivers of regional

programmes; and (b) the observed rate of decline in smoking prevalence rates over time in areas that put in place broader tobacco control programmes.

The evidence on Smoke free legislation suggests that 3% quit as a result of 20% attempting to quit because of legislation (28). The multi-component mass media is found to have achieved a quit rate of 3.9% (33). UK background quit rate over the last 40 years has been 1-2% as a result of quit attempts by 33% of current smokers (20). In California, 13% have quit with workplace and household smoking ban as a result of 55% making quit attempts resulting in a drop of 11% in smoking prevalence over 20 years (59,57,58). The North East of England has recorded 8% drop in smoking prevalence over 3 years immediately after implementing a regional tobacco control programme (39).

Putting these figures together, it is reasonable to assume that in the presence of national programmes alone 33% make quit attempts resulting in background quit rate of 2% (20). The presence of regional programmes, such as Californian Tobacco Control Programme, on top of the national programmes will attract another 25% to make quit attempts (note 55% made quit attempts in California). Applying the pathway model (20) then gives us the background quit rate of about 5% under regional programmes (Figure 1).

Figure 1: Estimating the background quit rate under regional programmes based on West 2006 (20) **'pipe' model**



In this report and accompanying economic tool, we have therefore used 5% as the default background quit rates in the presence of regional programmes. Whether this is accurate, overly optimistic and reflects the current situation in England is open to debate. However, the tool is flexible enough to be able to overwrite this with better estimates as and when they are available. To minimise uncertainty around this quit rate, one may run the analysis using different values and compare the results.

In passing, it is important to note that the difference in background quit rates when regional programmes are present or not will determine the scale of savings the tobacco control interventions are likely to make. Because regional programmes help more people to make quit attempts, there is always scope for tobacco control programmes to offer cost-savings under such programmes.

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